Simulation of cosmic Be isotopes detected by the RICH in AMS on the ISS

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A sample of cosmic ^{10}Be isotopes has been simulated in the expected experimental conditions for the forthcoming phase of the AMS experiment, and identified by means of the RICH counter. The results are discussed. The high flux proton component observed by AMS below the geomagnetic cutoff can be well accounted for by assuming these particles to be secondaries originating from the interaction of cosmic ray protons with the atmosphere. The simulation results are presented.

1. Introduction

The measurement of the ^{10}Be abundance is one of the main experimental goals in cosmic ray astrophysics of the AMS experiment. It is also highly representative of its discovery potential. Because of its long lifetime, the ^{10}Be isotope is used as a galactic chronometer for the measurement of the time of confinement of Cosmic Rays (*CR*s) in the galaxy (see refs [1] for example). The measurement of the momentum dependence of the $^{10}Be\,/^{9}Be$ ratio will provide a determination of important transport parameters and galactic variables: mean interstellar matter (ISM) density in the Leaky Box Model (LBM) [2], or size of the confinement halo in the diffusion model [3].

A realistic sample of simulated data for these ions with relevant counting statistics would provide a useful perspective on the physics achievable by the collaboration on this respect. It would also allow to evaluate both the usefulness of the performances considered for the RICH counter of the spectrometer in the current stage of the spectrometer design [4], and the relevancy of the instrumental options proposed for the final configuration of the RICH, in particular the choice of Čerenkov radiators. This contribution reports on such a simulation of the $^{10}Be/^{9}Be$ momentum distribution. The work is based on the simulation program developed for the RICH counter, and already used to work out the counter definition [5].

2. Simulation conditions

2.1. *CR* Event generator

The simulation used the natural $^{7,9}Be$ abundances [6], whereas the (theoretical) $^{10}Be/^{9}Be$ ratio and its momentum dependence, was taken from the LBM calculations reported in

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ref [7]. The momentum dependence of the $^{10}Be/^{9}Be$ ratio is shown on figure 2 (solid line).

2.2. AMS and RICH counter

A combination of two radiators considered for the final RICH counter configuration was used in the simulation. A radiator with large refraction index (sodium fluoride, NaF) allows to cover the lower momentum region of the sensitivity range of the counter (≈1-5 GeV/c per nucleon), whereas a low index radiator (Silica aerogel, n=1.025) covers the high momentum range (≈4-12 GeV/c per nucleon). The RICH counter is a proximity focused type of counter, as studied in ref [5]. Its dimensions were: Radiator diameter 140 cm, drift gap 40 cm, diameter of detector area 140 cm, with central dead area corresponding to the calorimeter location 70x70 cm inactive [4]. Light attenuation in light guides was taken into account in the simulation, as well as Rayleigh scattering for the aerogel radiator.

The two samples corresponding to NaF and AGL radiators have been generated in two seperate runs of the simulation program. Two superimposed radiator layers were assumed. This is a sensible procedure since it has been shown in prototype study that this type of configuration provides good results [8].

The momentum resolution of the spectrometer used for mass reconstruction, was estimated from the current status of the magnet and tracker architecture [4], using the relations given in ref [9]. The expected mean value is minimum in the central RICH sensitivity region around 3-10 GeV/c, of the order of $\frac{\Delta p}{p} \approx 1\%$, increasing on both sides [10].

The particle absorption in the matter of the spectrometer upstream of the RICH has not been taken into account. The thickness of matter will be about 5 g/cm^2 of material [4], i.e., ≈20% interaction length assuming $\Lambda_I \approx 25$ g/cm^2, which would damp the incoming Be flux by about the same fraction.

3. Results

The program was run for six weeks equivalent counting time of the experiment, which is expected to be running for several years. This is about 20 times less than the currently nominal full statistics expected. The results obtained are already highly significant however, and illustrate very well how the new data will compare with the existing ones, and how much AMS will improve on the current situation.

3.1. $^{10}Be/^{9}Be$ momentum distribution

The momentum range has been divided into 0.5 GeV and 1 GeV bins for NaF and aerogel radiator respectively. For each momentum bin, the mass spectrum has been fitted with gaussian shapes centered at the known value for the mass of the isotope. The results are shown on figure 1. It is seen that a good separation for Be ions is obtained over the range established in previous simulation studies [5], up to ≈5 GeV/c for NaF and ≈13 GeV/c for aerogel.

The final momentum distribution of the $^{10}Be/^{9}Be$ abundance ratio obtained from the sample of reconstructed ^{10}Be ions is shown on figure 2. It can be seen on this figure that the two radiators considered, NaF and Aerogel n=1.025, have very complementary momentum ranges and offer a wide overall momentum dynamics altogether, extending

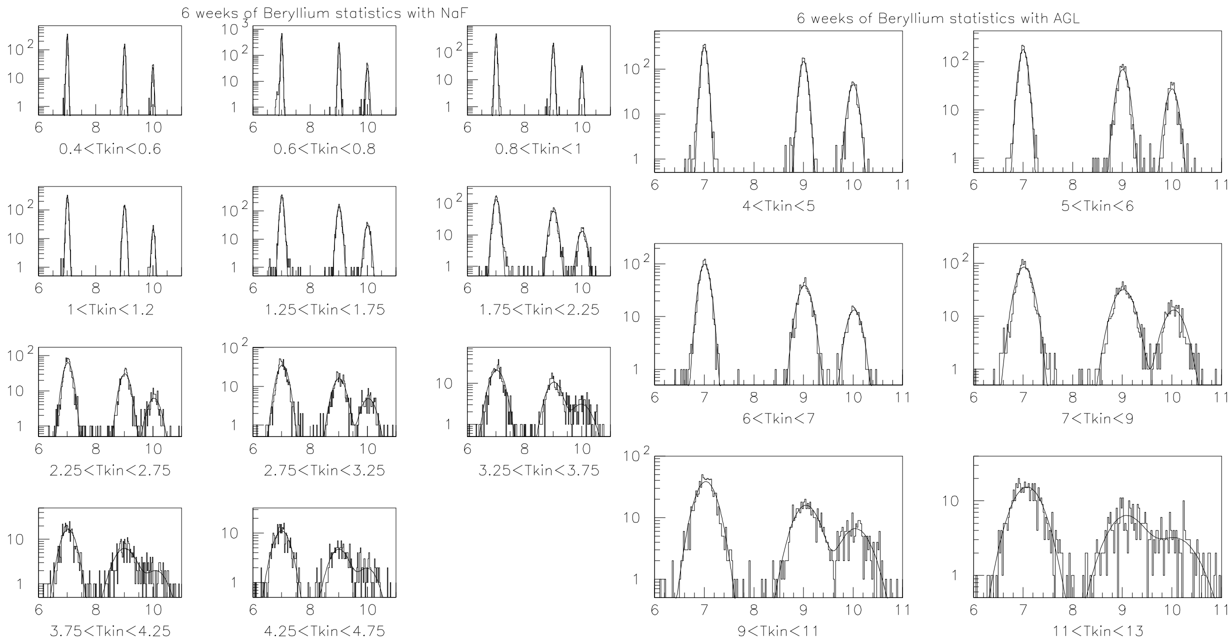

Figure 1. Mass distribution spectra for each momentum bin and corresponding fits for the three ions, obtained with NaF radiator (left) and Aerogel (n=1.025) radiator (right).

from below 1 GeV/c per nucleon at the lower end of the range for the NaF radiator, up to about 13 GeV/c per nucleon at the upper end of the range for the aerogel radiator. This is about the best possible range reachable with solid state radiators in the particular AMS conditions. It is also seen that this range nicely overlaps with the region of best sensitivity to the transport variables of Cosmic Rays. Using one single of the two radiators would severely truncate the momentum range one or the other side. Going for a compromise on the value of the refractive index like (aerogel) n=1.14 would truncate the momentum range from both sides, since no single radiator could achieve the coverage in momentum dynamics obtained here [5].

4. Conclusion

The simulation of the cosmic Be isotopes detected by the RICH of AMS has shown that the distribution of the ${}^{10}Be/{}^{9}Be$ ratio should be measured with unprecedented statistical accuracy and with a good precision over a momentum range for particle identification matching the domain of largest sensitivity of the ${}^{10}Be/{}^{9}Be$ ratio to the galactic propagation parameters. This momentum range can be covered only with a combination of two Čerenkov radiators such as sodium fluoride at low momenta, and silica aerogel (n≈1.025) at high momenta. A similar evaluation is being conducted for the ${}^{26}Al$ isotope.

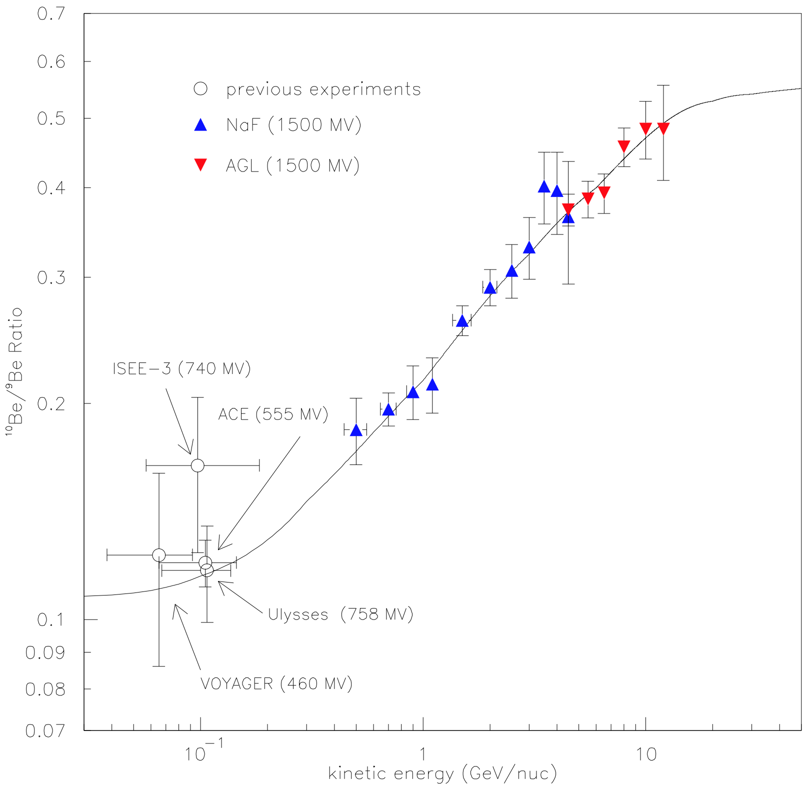

Figure 2. Expected $^{10}Be/^{9}Be$ ratio to be measured with AMS on the ISS over six weeks of counting time for each radiator of the RICH counter, NaF and aerofel. The value of the solar modulation parameter is given by the numbers in parenthesis for each experiment or simulation. The experimentaldata are from references [1].

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